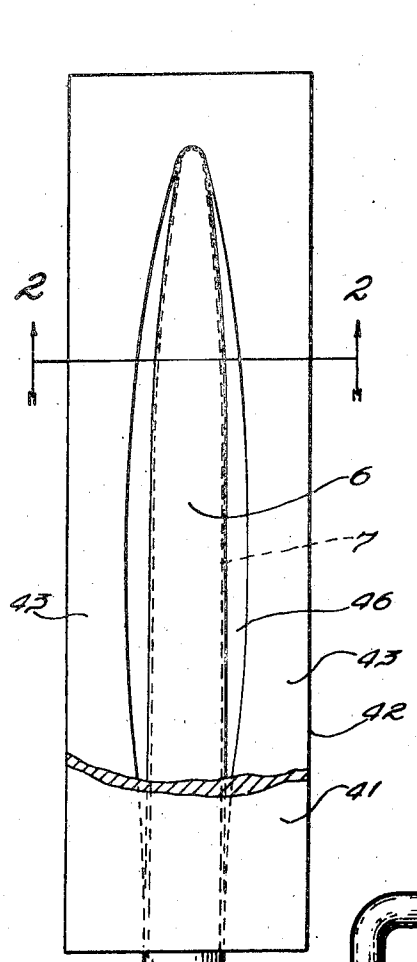
Sept. 19, 1933. J. SQUIRES 1,927,247

METHOD OF MAKING PROPELLER BLADES

Filed May 20, 1930



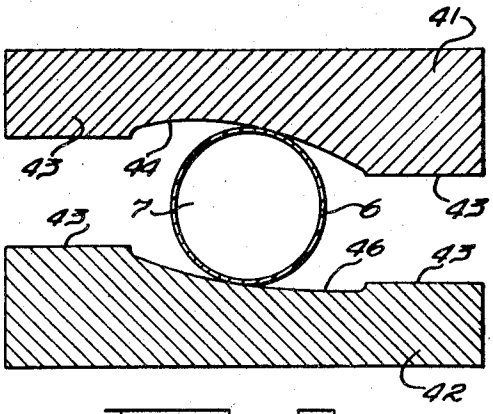


Fig. 2.

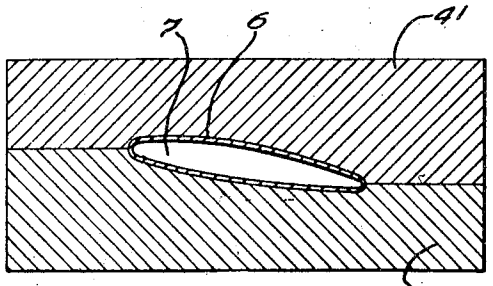


Fig. 3.

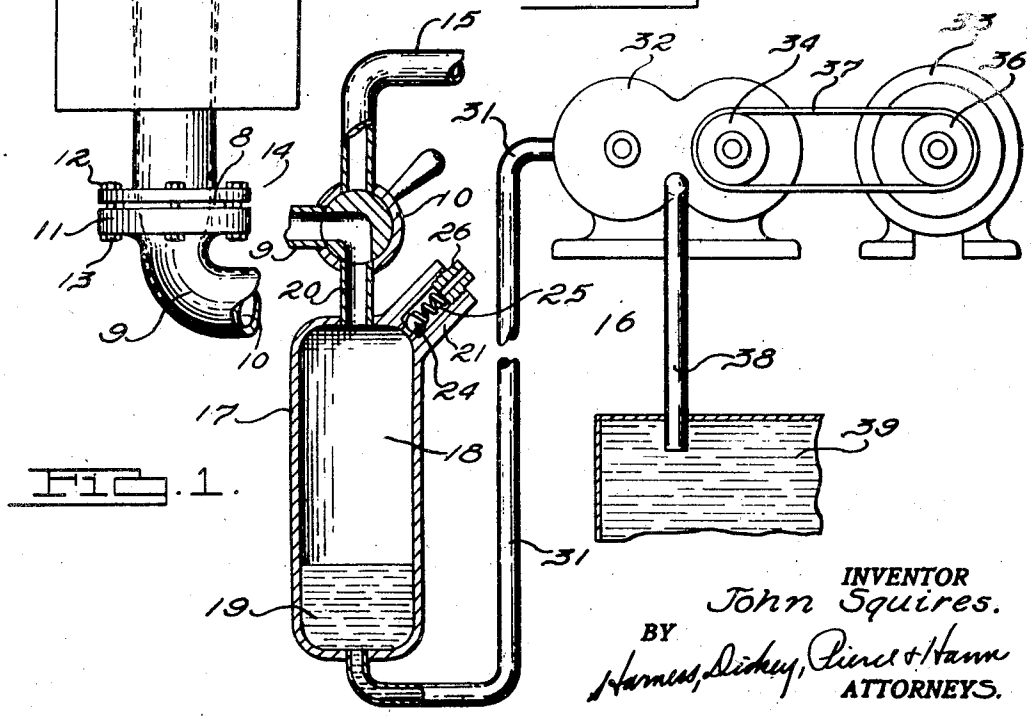


Fig. 1.

INVENTOR
John Squires.
BY
Harness, Dickey, Pierce & Hann
ATTORNEYS.

Patented Sept. 19, 1933 1,927,247

UNITED STATES PATENT OFFICE

1,927,247

METHOD OF MAKING PROPELLER BLADES

John Squires, Hagerstown, Md.

Application May 20, 1930. Serial No. 454,137

11 Claims. (Cl. 29—156.8)

This invention relates to a method of working metal tubes and to apparatus used to carry out this method, and has particular reference to certain steps in the manufacture of airplane propeller blades out of preheated tubes during which the tube is subjected to internal and external pressure.

One object of this invention is to provide, in a general pressing operation in which a tubular body is being changed in cross-section, suitable internal bracing, yielding and pressing means to cooperate with the external pressing means.

Another object is to provide such an internal bracing means and pressure forming means that will be applicable to the interior of a heated tube.

Another object is to provide a means for maintaining the interior of a heated tubular body under suitable pressure while simultaneously modifying the cross sectional shape thereof by external pressure, the means for providing such internal pressure being such as to result in a minimum amount of cooling effect on the body.

Another object is to provide compressed fluid supply means that will not allow any substantial expansion (and resultant cooling) of the fluid in entering the interior of the tube being processed.

Another object is to provide internal pressure means cooperating with the external pressure means during the pressing operation and then, after the external pressing has been completed, greatly increasing the internal pressure to insure exact conformance of the tubular body with the shape desired in the final product.

Another object is to provide suitable apparatus for carrying out such methods.

Numerous other objects and features of novelty will be apparent in the accompanying specification, claims and drawing, which show an illustrative embodiment of my invention wherein like reference numerals apply to like parts throughout the figures of the drawing.

In the drawing—

Fig. 1 is a more-or-less general diagrammatic, partially broken and partially sectioned view of a pressure supply apparatus, a tube or blank, and the dies to press the tube or blank, embodying an illustrative form of my invention.

Fig. 2 is a view showing the tube as placed between a pair of forming dies prior to the closing of the dies, the tube and dies being shown in section as taken on the line 2—2 of Fig. 1 looking in the direction indicated.

Fig. 3 is a view similar to Fig. 2 showing the relation of the parts after the forming dies have been brought together.

The method described in this application for patent is particularly useful in working or forming propeller blades of elongated tubular seamless steel closed tubes or blanks, but the method is equally applicable for use in connection with the forming of any type of hollow body wherein the cross-sectional shape of the hollow body is to be changed by compressing the article between forming dies.

In the process of forming objects from tubular blanks or tubes by pressure, considerable difficulty has been experienced where the change involved in the cross-sectional proportions of the article during the forming operation is relatively great.

The tendency to buckle, crack, or crinkle increases directly as the relative change in proportion increases, and previous efforts have failed where this change has been relatively great.

I avoid this difficulty by providing internal as well as external pressing means, by maintaining the tube hot during the process, by using a compressed internal pressing fluid that is given very little chance to expand and cool thereby, and by using a relatively small internal pressure during the closing of the dies and a relatively great pressure after they are closed.

In Fig. 1 such a tubular unit, for purposes of illustration a blank 6 for an airplane propeller, is shown as having a co-extensive internal cavity 7 and at its lower end is provided with an outstanding radial flange 8. A conducting pipe 9 is connected in communication with the interior of the blank 6 by means of a flange 11 on the conducting pipe. The lower annular surface of the outstanding radial flange 8 on the blank 6 and the flange 11 on the conducting pipe are drawn into contacting relation by means of nuts 12 and bolts 13 and a ring flange 14 received over the blank 6.

These surfaces may be provided with any suitable means such as gasket packing or by a ground fit between the respective surfaces thereof, to prevent any substantial loss of fluid therebetween during the forming process.

The communicating pipe 9 extends to a selective supply valve 10 and is thereby selectively connected to an air line 15, or to a high pressure air compressor generally designated as 16, to permit the interior of the blank to be selectively filled with low or high pressure air. It may be noted that in Fig. 1 the compressor assembly 16 is shown on a considerably more reduced scale than the other portion of the figure.

The air line 15 may be the usual type of shop

air line used in most foundries and other shops and contains air which may be under a pressure of 100 lbs. per square inch and having the usual supply means therefor, although it will be understood that pressures between 50 lbs. per square inch and 500 lbs. per square inch may be practical for this operation depending upon circumstances.

The air compressor 16 preferably consists of a compression tank 17 in which a compressible fluid such as air 18 is compressed by its displacement by an uncompressible fluid such as water 19. I prefer to provide a relief valve for the tank 17 and consequently I rigidly secure to a portion of the upper wall of compression tank a relief valve casing 21 enclosing a valve-forming ball 24 constantly urged towards closed position by the spring 25 as in conventional constructions. The hollow stop 26 for the opening 25 is threaded into the casing 21 whereby it may be employed for varying the tension of the spring 25 and thereby control the maximum pressure capable of being maintained in the tank 17.

The compression chamber contains two fluids in varying volume. A compressible gas 18 such as air occupies the upper portion of the chamber and under pressure passes into the communicating pipe 9.

A substantially uncompressible liquid 19 such as water occupies a varying volume of the lower portion of the compression chamber and is fed thereto by a conducting pipe 31 from a hydraulic pump 32 actuated by an electric motor 33, or other suitable source of power. The hydraulic pump 32 may be any usual type of positive acting pump and is shown in this embodiment for the purpose of illustration as a usual type of gear pump driven by an electric motor by means of pulleys 34 and 36 and belt 37, and obtaining its supply of water by means of a water supply pipe 38 running to a convenient source of water 39.

In Figs. 2 and 3 the forming dies 41 and 42, between which the blank is adapted to be received and be modified in cross-sectional shape thereby, are provided with flat surfaces 43 for limiting their travel and with forming surfaces or depressions 44 and 46 which give to the article being formed in the dies the desired cross-sectional and other configuration. These dies may be operated by a hydraulic press, the hydraulic cylinder of which may be actuated by water pressure from the pump 32.

The circumference of the tube or blank 6, at any transverse section thereof, is preferably in exact conformance to the perimeter of the depressions 33 and 46 as measured in a plane corresponding with such transverse section. Because of this the circumference of each increment of length of the tube is equal to the perimeter of the corresponding increment of length of the finished article and the metal of the tube, while bent to a new and different shape, is not elongated or compressed in any part of its internal structure during the process. Because of this the material of the tube or blank is not subjected to such stresses as would tend to rupture or weaken it or cause it to fold up or crinkle during the forming operation.

The operation is as follows: The relief valve 21 is set to yield at a suitable predetermined pressure which may be, for example 3,000 pounds to the square inch, although the pressures may range from 1,000 to 10,000 lbs. per square inch depending upon circumstances.

The tube 6 is heated in a furnace (not shown) until it reaches a suitable predetermined heat, which may be between 2282 degrees Fahrenheit and 1652 degrees Fahrenheit for soft steel, or between 1922 degrees Fahrenheit and 1292 degrees Fahrenheit for steel with a carbon content of .85 per cent or greater carbon percentage.

When the tube reaches the predetermined heat it is withdrawn from the furnace and placed between the dies. The conducting pipe 9 is then rigidly and detachably secured thereby by means of the described attaching means 11, 12 and 13 or any other suitable attaching means. The valve 10 is then turned to admit air from the shop air line 15 to the conducting pipe 9.

Because the communicating pipe 9 preferably has an internal passage 10 comparable in diameter with the interior 7 of the tubular blank 6 and the pipe 15 of the shop air line, the compressed air in passing into it from the shop air supply (not shown) does not materially expand, but is compressed all along the line, avoiding the cooling effect that would be caused by expansion through a restricted orifice.

The dies 41 and 42 are now brought together on the blank 6 and as they come together they press the blank between them and the internal pressure of the air tends to prevent collapsing of the blank beyond that defined by the die depressions and prevents any tendency of the tube to crinkle or buckle.

As soon as the die halves are brought together the valve 10 is turned so that it is in the position shown in Fig. 1, which allows the passage of air from the compression chamber 18 into the conducting pipe 9.

At this point there may or may not be any water in the compression tank 17. If not, then as soon as the valve 10 connects it to the blank 6 the motor 33 is started which causes the pump 32 to force water from the supply 38 into the compression chamber 17 wherein it compresses the air until the relief valve 21 opens at the set pressure which may be 3000 lbs. per square inch. On the other hand, the air within the tank 17 may be brought to a suitable pressure before the valve 10 is turned to connect the blank with the tank 17, in which case this pressure is immediately applied to the interior of the blank when the valve 10 is turned as above described.

Because the communicating pipe 9 has an internal passage 10 comparable in diameter with the interior 7 of the tubular blank 6 and the pipe 20 leading to the compression chamber, the compressed air 18 in passing into it from the compression chamber 17 does not materially expand, but instead is compressed all along the line avoiding the cooling effect that would be caused by the expansion of air through a restricted orifice into the hollow interior of the tubular blank.

Inasmuch as air has a very low specific heat, and inasmuch as its temperature is not materially lowered by expansion in being introduced into the blank, the reduction of the temperature of the blank due to the introduction of the air into it is substantially negligible, and this feature is of prime importance.

The great pressure of this air on the interior of the blank forces the heated metal thereof evenly and firmly outwardly against the surfaces of the depressions 44 and 46 and causes the tube to take the exact internal shape of the depressions, straightening out any crumpled parts thereby, and setting the crystalline structure of the metal of the tube so that it will thereafter exactly maintain its pressed form. It may be left under

this pressure until below the critical temperature (1652° Fahrenheit for soft steel and 1292° Fahrenheit for .85 carbon steel) corresponding to the material, after which the air pressure may be relieved, the die halves separated, and the blank removed from the dies and disconnected from the pipe 9.

Under certain conditions the same method may be used throughout, utilizing the same apparatus and the same tubular blank, but omitting the heating of the tubular blank, as under certain favorable circumstances the preheating of the blank is unnecessary.

The advantages of this method are too numerous to properly enumerate; by means of this hot, dry elastic gas in the interior of the blank furnishing forming pressure during the operation greater changes in cross-section may be accomplished than would be normally possible, and by use of the final high pressure exact conformance of the finished blade to the desired shape and contour is assured.

While I have shown in the drawing a particular illustrative form of my apparatus various modifications may be made in the same and in the various features of construction without materially changing the invention therein, and formal changes may be made in the specific embodiment of the invention described without departing from the spirit or substance of the broad invention, the scope of which is commensurate with the appended claims.

I claim:

1. In the formation of a propeller blade from a tubular metallic blank by modifying the cross-sectional shape thereof between a pair of dies, the successive steps of subjecting said blank to a material internal expansive pressure during closing of the dies and a materially greater internal expansive pressure thereafter while maintaining said dies in fully closed positions.

2. In the formation of a propeller blade from a hollow metallic blank, the method of bringing said blank to the desired cross-sectional shape comprising placing said blank between a pair of dies having matching depressions of the desired size, shape and contour, subjecting said blank to an internal expanding pressure of from 50 to 500 lbs. per square inch while bringing said dies together, and then increasing said pressure to from 1,000 to 10,000 lbs. per square inch while the dies are fully closed.

3. The method of forming a hollow metal propeller blade from a tubular blank, comprising heating said blank, placing said blank in heated condition between a pair of dies having matching depressions therein of the desired shape and size, bringing said dies together while maintaining the interior of said tube under internal pressure to resist inward collapsing of the walls thereof, and then subjecting the interior of said blank while said dies are retained in fully closed positions to an increased internal pressure sufficient to work the crystalline structure of the metal of said blank.

4. The method of shaping a metal tube which consists in die pressing it externally, and expansively pressing it internally gently during the die pressing by the admission of gas under moderate pressure, and then firmly expansively pressing it internally by the admission of gas under a greater pressure while braced against undesirable expansion by said die.

5. The method of shaping a metal tube which consists in die pressing it externally, expansively pressing it internally gently during the die pressing, and then firmly expansively pressing it internally while maintained between said dies in fully closed condition.

6. The method of shaping a metal tube which consists in heating the tube, die pressing it externally, and expansively pressing it internally gently during the die pressing, and then firmly expansively pressing it internally while braced against undesirable expansion by said dies.

7. The method of shaping a metal tube which consists in heating the tube, die pressing it externally, and expansively pressing it internally gently during the die pressing and then firmly expansively pressing it internally while the dies are held together in fully closed relation.

8. The method of shaping a metal tube which consists in heating the tube, pressing it internally and externally simultaneously into final shape, and then bracing it in final shape externally and internally expansively pressing it with force materially greater than that employed in the first internal pressing operation.

9. The method of shaping a metal tube which consists in heating the tube, pressing it internally and externally simultaneously into final shape, and then bracing it in final shape externally and pressing it internally with a materially increased expansive pressure that would rupture it if not so externally braced.

10. The method of shaping a metal tube which consists in heating the tube to above its critical temperature, pressing it internally and externally simultaneously into final shape, said internal pressing being accomplished by a fluid under pressure, and then bracing it in final shape externally and internally expansively pressing it with a force relatively greater than that employed in the first mentioned internal pressing operation, until it is below its critical temperature.

11. The method of shaping a metal tube which consists in heating the tube to a temperature above the critical point of the metal, pressing it internally and externally simultaneously into final shape, and then bracing it in final shape externally and internally expansively pressing it with a force materially greater than that employed in the first mentioned internal pressing operation.

JOHN SQUIRES.